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Using Tariff Indices to Evaluate Preferential Trading Arrangements

An Application to Chile

Eric Bond

A tariff index that, combined with a simple general equilibrium model, can be used to calculate more accurately how preferential tariff reductions affect sectoral output, factor prices, average tariff rates, and general welfare.

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Summary findings

Bond presents a tariff index that uses constant-elasticity-of-substitution aggregators of tariff line data to calculate how preferential tariff reductions affect both prices and average tariff rates.

A simple general-equilibrium model with sector-specific factors of production can be combined with the tariff indices to calculate how a preferential trade arrangement affects sectoral output, factor prices, and general welfare. The general equilibrium model is simple enough that it can be calculated on an Excel spreadsheet, and is flexible enough to be used with different ranges of available domestic data.

Bond presents an example of the model, simulating the effects of free trade agreements between Chile and MERCOSUR countries and between Chile and NAFTA countries.

Calculations for the case of Chile show that the index is simple to calculate because of its recursive structure, which allows large amounts of detailed tariff line data to be aggregated for use with domestic production data that is available only at a more aggregated level.

Bond finds that results using the tariff aggregators may differ substantially from those derived using simple averages of tariff reductions. Reductions in import prices using the index were 10 to 30 percent larger than those calculated using a simple average of tariffs. Ignoring the information available in tariff line data could lead to a substantial overestimate of the average tariff rate on imports after a preferential reduction.

The tariff index could be extended to incorporate the role of quantitative restructions. The general equilibrium model could be used to consider the effects on domestic production of allowing reallocation of capital between industries over time.

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Using Tariff Indices to Evaluate Preferential Trading Arrangements:
An Application to Chile*

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Foreword

As regional trading arrangements (RTAs) have spread, enlarged and deepened over the last decade, they have posed challenges to economists on both intellectual and policy levels. On the former, do RTAs stimulate growth and investment, facilitate technology transfer, shift comparative advantage towards high value-added activities, provide credibility to reform programs, or induce political stability and cooperation? Or do they, on the other hand, divert trade in inefficient directions and undermine the multilateral trading system?

The answer is probably "all of these things, in different proportions according to the particular circumstances of each RTA." This then poses the policy challenge of how best to manage RTAs in order to get the best balance of benefits and costs. For example, should technical standards be harmonized and, if so, how; do direct or indirect taxes need to be equalized; how should RTAs manage their international trade policies in an outward-looking fashion?

Addressing these issues is one important focus of the research program of the International Trade Division of the World Bank. It has produced a number of methodological innovations in the traditional area of trade effects of RTAs and is now starting to tackle four new areas of research: the dynamics of regionalism (e.g., convergence, growth, investment, industrial location and migration), deep integration (standards, tax harmonization), regionalism and the rest of the world (including its effects on the multilateral trading system), and certain political economy dimensions of regionalism (e.g., credibility and the use of RTAs as tools of diplomacy).

In addition to thematic work, the program includes a number of studies of specific regional arrangements, conducted in collaboration with the Regional Vice Presidencies of the Bank. Several EU-Mediterranean Association Agreements have been studied and a joint program with the staff of the Latin American and Caribbean Region entitled "**Making the Most of Mercosur**" is under way. Future work is planned on African and Asian regional integration schemes.

Regionalism and Development findings have been and will, in future, be released in a number of outlets. Recent World Bank Policy Research Working Papers concerning these issues include:

> Glenn Harrison, Tom Rutherford and David Tarr, "Economic Implications for Turkey of a Customs Union with the European Union," (No. 1599).
>
> Maurice Schiff, "Small is Beautiful, Preferential Trade Agreements and the Impact of Country Size, Market Share, Efficiency and Trade Policy," (No. 1668).
>
> L. Alan Winters, "Regionalism versus Multilateralism," (No. 1687).

Planned future issues in this series include:

> Sherry Stephenson, "Standards, Conformity Assessments and Developing Countries"
>
> Maurice Schiff and L. Alan Winters, "Regional Integration as Diplomacy"

Magnus Blomström and Ari Kokko, "Regional Integration and Foreign Direct Investment: A Conceptual Framework and Three Cases"

Magnus Blomström and Ari Kokko, "The Impact of Foreign Investment on Host Countries: A Review of Empirical Evidence"

Anthony Venables and Diego Puga, "Trading Arrangements and Industrial Development"

L. Alan Winters and Won Chang, "Integration and Non-Member Welfare: Measuring the Price Effects"

Glenn Harrison, Thomas Rutherford and David Tarr, "Trade Policy Options for Chile: A Quantitative Evaluation"

In addition, **Making the Most of Mercosur** will be issuing papers over the next few months, including:

Alexander J. Yeats, "Does Mercosur's Trade Performance Raise Concerns About the Effects of Regional Trade Arrangements?"

Claudio Frischtak, Danny M. Leipziger and John F. Normand, "Industrial Policy in Mercosur: Issues and Lessons"

Sam Laird (WTO), "Mercosur Trade Policy: Towards Greater Integration"

Margaret Miller and Jerry Caprio, "Empirical Evidence on the Role of Credit for SME Exports in Mercosur"

Malcom Rowat, "Competition Policy within Mercosur"

For copies of these papers or information about these programs contact Maurice Schiff, The World Bank, 1818 H Street NW, Washington, D.C. 20433.

An additional major outlet for World Bank-sponsored research on regionalism will be the Annual Bank Conference on Development in Latin America, 1997, Montevideo, June 30-July 2, 1997, organized by the Office of the Chief Economist and the Technical Department for Latin America and the Caribbean Region, with the support of the International Trade Division and the Economic Development Institute.

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Director
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This paper presents a model for analyzing the effects of entry into a preferential trading arrangement on the welfare of a small open economy, and reports results of its application to the case of Chile's entry into NAFTA or MERCOSUR. It has been known since the seminal work of Viner (1950) that entry into a preferential trading arrangement (customs union or free trade area) has an ambiguous effect on welfare. The benefit obtained from entry into a preferential trading arrangement is an empirical question that must be decided from the characteristics of the member countries and their trade patterns. Unfortunately, the concepts of trade creation and trade diversion that Viner used to describe the effects of a customs union do not in general have direct interpretations as components of welfare measures obtained from utility maximization.[1] Therefore, it is necessary to develop a measure of the effects of preferential tariff reductions that has a direct welfare interpretation.

The model presented in this paper consists of two components. The first is an aggregation procedure for creating aggregate import goods from data on trade volumes and tariff rates at the tariff line level available in the SMART system. This aggregation procedure is based on the assumption that imports are separable from domestic production and consumption. This approach is similar to that adopted by Anderson and Neary (1991) and Anderson (1991), who develop index numbers for summarizing the effects of a country's tariff structure. In order to apply this approach to tariff reductions that discriminate between countries, we extend these tariff indices by allowing for imperfect substitutability between goods in the same tariff line classification that come from different countries. The aggregation procedure uses nested constant elasticity of substitution (CES) functions, which allows for the substitutability between products from different countries (in the same category) to differ from that of products in different categories. This aggregation procedure yields two components: a measure of the effect of preferential tariff cuts on the relative price of the composite imported goods and a measure of the average tariff rate on the composite goods.

The second component is a general equilibrium model of the domestic economy which uses the changes in the composite import prices and average tariff rates from the CES aggregation to calculate the effects of tariff changes on domestic activity levels, tariff revenue, and welfare. This model is designed to be sufficiently simple that it can be calculated on an EXCEL spreadsheet, and to be flexible enough to allow application under differing degrees of availability of domestic data. The spreadsheet model yields an index of the effect of the preferential tariff reductions which is dependent on the assumptions made regarding the domestic production structure.

The structure of this model reflects the desire to combine information on tariffs and trade volumes, which is available at a very fine levels of product classification, with data on domestic input usage and consumption, which is available only at much more highly aggregated levels. By assuming separability between domestically produced goods (traded and non-traded) and imported goods in the production functions and utility function, we are able to combine data from these two different sources and obtain simple measures of the welfare effects of preferential tariff cuts. Chile presents an interesting example application of the model for several reasons. First, the initial tariff structure in Chile is essentially a uniform external tariff. The literature on tariff reform (Hatta (1977), Corden (1984)) has suggested that under certain conditions, welfare improvements can be obtained by either (i) a proportional reduction in all tariffs or (ii) tariff changes that move in the direction of a uniform external tariff (e.g. a reduction in the highest tariff rate and an increase in the lower tariff rate). This raises questions about the benefit of entry into a preferential trading arrangement for Chile, since it results in a movement away from a uniform external tariff. Second, the availability of two alternative preferential trading arrangements has the potential to provide insights about which types of preferential trading arrangements would be most desirable.

I. Aggregation of Trade Data

In this section, we present a procedure for aggregating tariff line level data using nested CES functions that is compatible with domestic data on consumption and input use. The trade data consists of import values and base tariff rates for N tariff lines from H different source countries. We will assume imports from different countries are imperfect substitutes, and that the importing country is a small country in world markets. These assumptions ensure that a change in tariff policy, whether it applies to all goods in a particular tariff line or only those from a particular source country, will have no effect on the world prices of any of the imported goods. The domestic production data is assumed to contain data on imports in I_M product categories, which are used as intermediate inputs in domestic production and/or as consumption goods. The problem is to aggregate the NxH import values to I_M composite imported goods.

The aggregation problem for a particular product category i is illustrated in Figure 1. The nodes at the top (denoted by a I) of the Figure represent the value of imports in industry i, denoted M_i, that are utilized as intermediate inputs or consumption goods in industry i in the domestic data. The entries at the bottom of the Figure correspond to the trade data, which is the value of imports by tariff line and source country. We will develop a quantity index, Z_i, and a price index, ϕ_i, for each sector i such that $Z_i\phi_i = M_i$. In addition, we will obtain an index of the average tariff rate, t_i , such that tariff revenue for each sector i is t_i Z_i. The effect of tariff policy changes on ϕ_i and t_i will then be utilized in the general equilibrium model to calculate the effect on domestic output, employment, and welfare.

Nested CES aggregation is used to allow for different degrees of substitution within product categories than between product categories. First, we allow for the possibility that goods in the same industry group have a different degree of substitutability for each other than for goods in another industry group. In the example illustrated in Figure 1, this is done by dividing each of the industry groups into J_i subgroups. Each tariff line is then classified into an industry and a sub-industry. This results in each tariff line being identified by a triple {i,j,k}, where i is an indicator of the industry to which it belongs, j is an indicator of the sub-industry to which it belongs, and k is an indicator of the tariff line within the sub-industry. Second, we allow for the possibility of different degrees of substitutability between goods from different country groups. For example, we can let goods from high income countries be better substitutes for each other than for imports from low income countries in the same product category. This is accomplished by dividing countries into groups, and assigning each source country to a country group. Each country will thus be identified by a pair {l,m}, where l is an indicator of the country group to which it belongs and m is an indicator of the country within the country group.

The trade data on import values from a particular source country in a particular tariff line are denoted by M_{ijklm} at the bottom of Figure 1, where the {ijk} subscripts identify the tariff line and the {lm} subscripts identify the source country. The tariff rates imposed on imports from that product category and country can similarly be identified by t_{ijklm}. The aggregation proceeds by first aggregating over imports within a particular country group, as indicated by node IV in Figure 1. The trade value $\mathbf{M_{ijkl}} = \sum_{m} \mathbf{M_{ijklm}}$ represents the value of imports from country group l in tariff line {i,j,k}, with ϕ_{ijkl} the price index for this group and Z_{ijkl} the quantity index. The data on imports from country groups at node IV is then aggregated over the groups within the tariff line to yield a price index ϕ_{ijk} and quantity index Z_{ijk} for the tariff line (at node III). The tariff lines within each sub-industry are then aggregated to yield indices for the sub-industry (node II), and the sub-industry indices are aggregated to obtain the industry aggregate at node I.

The aggregation structure is quite flexible, and can be extended to allow for any number of levels of industry and/or country groups. The application to Chile considered in this section provides an example of how the aggregation can be carried out. The trade volume data from Chile consist of 1011 tariff lines at the 4-digit (CCCN) level for the year 1986. This trade data had to be aggregated to 41 different product categories, which represented the industries for which import usage data were available in the input-output table of the Chilean economy for 1986.[2] The aggregation first accomplished by dividing these 41 industries into sub-industries using SITC classifications, leading to a total of 113 sub industries (corresponding to the number of nodes at level II in Figure 1). Each of the tariff lines (nodes at level III) was then assigned to a subindustry using an CCCN/ SITC concordance. To allow differing degrees of substitutability between different types of countries, the source countries were divided into three groups: OECD countries, Latin American countries, and the rest of the world. There were thus a total of 3,033 nodes at level IV in Figure 1, resulting from 3 country groups for each of the tariff lines.

At each node, a CES aggregator is used to derive a quantity and price index from the price and quantity indices at the lower level nodes. For example, let A denote a representative node and let A_i be the nodes that are connected to A at the next lower level of aggregation. We want to develop an aggregate index for node A, Z_A from the indices Z_{A_i} calculated at the lower level nodes. The

aggregate quantity at node A will be

$$Z_A = \left[\sum_i (b_{A_i} Z_{A_i})^{\frac{\sigma_A - 1}{\sigma_A}} \right]^{\frac{\sigma_A}{\sigma_A - 1}} \tag{1}$$

where $\sigma_A \in [0, \infty)$ is the elasticity of substitution between imports from the different inputs to node.[3]

The parameters b_{A_i} are included to allow for the possibi

lity of quality differences between goods from different input sources. The corresponding price index for goods at node A will be

$$\Phi_A \equiv \left[\sum_i \left(\frac{\Phi_{A_i}}{b_{A_i}} \right)^{1-\sigma_A} \right]^{\frac{1}{1-\sigma_A}} \tag{2}$$

where ϕ_{A_i} is the price index of goods from the component groups that make up the aggregate at node A.

This aggregation structure implies that the share of total expenditure on imports at node A that come from category Ai will be

$$\beta_{A_i} \equiv \frac{\phi_{A_i} Z_{A_i}}{\phi_A Z_A} = \left(\frac{\phi_{A_i}}{b_{A_i} \phi_A} \right)^{1-\sigma_A} \tag{3}$$

Equations (1)-(3) summarize the quantity, price, and expenditure share at a representative node.

In practice, data on the value of trade in each category is normally available but data on the quantities of imports are unavailable or unreliable. This means that it will not be possible to separately identify the b_{A_i} parameters from the data. Therefore, there is no loss of generality in normalizing prices of all imports to 1 in the initial situation. Under the assumption that the country in question is small and that goods from different source countries are imperfect substitutes, the domestic price of the imported goods in the tariff line data will be $(1+\tau^0_{ijklm})\, q^*_{ijklm}$, where q^*_{ijklm} is the exogenously given foreign price of goods in the tariff line with index ijk from the country whose index is lm and τ^0_{ijklm} is the ad valorem tariff imposed in the initial situation. The normalization of domestic prices to 1 in the initial situation is thus a normalization of world prices to $1/(1+\tau^0_{ijklm})$ in the initial situation. Assuming that prices in the rest of the world remain unchanged, the new domestic price will be $\phi_{ijklm} = (1+\tau^1_{ijklm})/\,(1+\tau^0_{ijklm})$, where τ^1_{ijklm} is the new tariff rate .

Under this normalization, $\phi_{A_i} = 1$ for all nodes A and sub-indices i in the initial situation and the b_{A_i} parameters can be derived from the expenditure shares in the initial situation (denoted

by a 0 superscript) to be $\beta^0_{A_i} = \dfrac{M^0_{A_i}}{M^0_A} = b_{A_i}^{1-\sigma_A}$. From (2), the price index for the effect of the tariff

change at node A will be

$$\phi_A = \left[\sum_1 \beta^0_{A_i} (\phi_{A_i})^{1-\sigma_A}\right]^{\frac{1}{1-\sigma_A}} \tag{4}$$

Note that for $\sigma_A = 0$, (4) becomes a simple weighted average of the price changes within the category, where the weights are equal to the shares of the value of trade of the respective products within the category.

The aggregation procedure thus consists of calculating the price index (4) at each of the nodes for a particular change in the tariff structure. Note that if the tariff cut were a uniform cut such that $(1+\tau^1_{ijklm}) = \lambda\,(1+\tau^0_{ijklm})$ for all i,j,k,l, and m, then $\phi_i = \lambda$. Thus, ϕ_i can be interpreted as indicating the uniform tariff cut in category i that would have the same effect on import prices as the tariff policy change being considered. Note also that $\ln \phi_i$ will be an approximation of the percentage change in import prices in industry i resulting from this uniform tariff cut.

A. Trade Shares and Average Tariff Rates

Once the effects of tariff cuts on the price indices have been calculated, the price indices can be used to calculate the effect of the tariff changes on the trade shares in the product categories and on tariff revenue. Using (3), the share of imports in product category A coming from the subcategory with index i will be

$$\beta^1_{A_i} = \beta^0_{A_i}\left(\frac{\phi_{A_i}}{\phi_A}\right)^{(1-\sigma_A)} \tag{5}$$

When the elasticity of substitution is greater (less) than one, the expenditure on imports in a particular sub-category as a share of imports in the total category will rise (fall) if the price of imports in that category falls relative to the price of goods in the category as a whole.

Now consider the effect of the change in tariff structure on tariff revenue. Under the normalization we have adopted, each unit of good {ijklm} imported yields tariff revenue of

$t_{ijklm} \equiv q_{ijklm} - q^*_{ijklm} = \dfrac{\tau_{ijklm}}{1+\tau_{ijklm}}$. We can then derive the tariff revenue collected from a unit of

expenditure at node A, denoted t_A, to be the weighted average of tariff revenues of the components A_i, where the weights are the respective trade shares.

$$t_A = \sum_i t_{A_i}\beta_{A_i} \tag{6}$$

Similar calculations can be performed at each node in Figure 1 to yield the tariff revenue generated by an additional unit of expenditure at that node.

Starting from an initial tariff structure for industry i as summarized by t^0_i, the pair (ϕ_i, t^1_i) captures the effect of the change in the tariff structure on imports in industry i. This means that any two changes in the tariff structure that yielded the same values (ϕ_i, t^1_i) would have the same effect on composite import prices and tariff revenue from the composite goods in industry i.

B. An Application to Chile

In this section we illustrate the calculation of the import price indices to capture the effects on relative prices in Chile of eliminating tariffs on MERCOSUR and NAFTA countries. Table 1 reports the calculations of the impacts for the 15 largest import sectors (out of the total of 41 sectors calculated) as well as the trade-weighted average over all 41 sectors. Column 1 reports the shares of the respective industries in total imports in 1986. These trade shares indicate that Chile's imports were concentrated in manufactured goods, particularly capital-intensive or R&D intensive sectors. Imports from 5 of these industries (chemicals, electrical machinery, transportation equipment and basic metals) account for 55% of imports. Column 2 shows that the tariff structure rates prior to entry into preferential arrangements, denoted BASE rate, was virtually a uniform tariff of 11%. Column 3 shows the tariff rate by import category, NEW rate, calculated using a simple trade-weighted average of all goods in each of the product categories. Table 1 shows that reducing tariffs on MERCOSUR members has a relatively small effect on the overall average tariff rate over all imports, which falls from 11% to 9.4%. Entry into MERCOSUR has a significant impact on the average tariff rate in 8 of the individual product categories, where the tariff rates fall to below 10%. The significant cuts occur primarily in industries associated with agricultural production (meat, leather, tobacco, sugar) and simple manufacturing processes associated with agriculture (leather, oils and fats, and processed vegetables). However, these products represent a relatively small volume of Chile's trade, with none making the list of the 15 largest sectors. Therefore, the overall effect on the average is quite small. Column 4 converts the tariff cut into a percentage reduction in the price of imports, using the formula ln(1+BASE)-ln (1+NEW). This tariff cut averages about 1.4% for MERCOSUR, compared with a cut of 10.4% (i.e. ln (1.11)) if the tariff rate had been cut to 0 on all imports.

Columns 5 and 6 present calculations of the price index under two alternative assumptions regarding the elasticity of substitution. For column 6, referred to as the high elasticity assumption, it was assumed that $\sigma_i = .9$, $\sigma_{ij} = 2$, $\sigma_{ijk} = 16$, and $\sigma_{ijkl} = 32$ for all i, j ,k , l. The value of 16 for the country group level was obtained by taking the average of elasticities estimated by Grossman (1982) between developed country (DC) and less developed country (LDC) imports in the US. The remaining elasticities were chosen by assuming that substitution would be greater at lower levels in the aggregation structure in Figure 1. These assumptions yielded reductions in the price of the composite imports of as much as 3-4% in some of the significant sectors. The average reduction in the price of imports of 2.2%, which is 50% more than the price cut obtained using the simple weighted average measure in Column 4. This would be equivalent to a uniform external tariff of 8.6%. The reason for this difference is that the CES structure allows more substitution toward imports that are treated preferentially than does the simple weighted average, which results in a larger reduction in the effective price of imports. Column 5 shows the results obtained if the elasticities take the values $\sigma_i = .9$, $\sigma_{ij} = 2$, $\sigma_{ijk} = 4$, and $\sigma_{ijkl} = 8$, which is referred to as the low elasticity assumption. In this case the elasticities at the country level were taken to be one-quarter of those in the high elasticity assumption, which are closer to those typically used in CGE models.[4] Under the low elasticity assumption, the tariff cut is equivalent in a reduction in the external tariff to a uniform value of 9.2%, which is only slightly lower than the value of 9.4% obtained with the simple weighted average. Under either set of elasticity assumptions, the effects on import prices of reducing tariffs on MERCOSUR members is much smaller than that obtained from a complete elimination of tariffs.

Table 2 shows that the tariff cut for NAFTA would be more significant, with the simple average tariff falling to 8.3%. The effects of entry into NAFTA are more evenly distributed across import categories than are the MERCOSUR cuts, with most of the average tariff rates still exceeding 7% under NAFTA. In only two of the product categories does the average tariff under NAFTA fall below 5%. However, the effect on the average tariff rate is more significant because of the larger trade volume with NAFTA countries. The average drop in import prices using the simple weighted average is 2.5 % (Column 4). Using the CES aggregation, the cut is equivalent to 3.62% using the higher elasticity assumption in Column 6, and 2.8% under the lower under the lower elasticity assumption. These are equivalent to reductions in the uniform external tariff to 7% and 8%

respectively.

Table 3 shows the effects of the respective tariff cuts on the tariff revenue per dollar of expenditure on import good i, t_i. Column 2 shows the value in the initial situation, where the uniform external tariff of 11% yields a value of $t = (0.11/1.11) = .099$. Columns 3 and 4 show the effect on average tariff rates of elimination of tariffs on MERCOSUR countries under the low and high values for the elasticity of substitution, respectively. For the low value, the values of t_i for the major categories fall in the range of 7-9%, with the simple weighted average across all sectors equaling 8.2%. Under the high assumption regarding elasticities of substitution, many of the tariff rates are in the 5-8% range and the average falls to 7.1%. Average tariff rates for entry into NAFTA were lower than those for MERCOSUR, with the average rate falling to 7.1 % under the low elasticity assumption and 5.4% under the high elasticity assumption.

One interesting point to note regarding these calculations is that when tariff cuts are preferential, the uniform tariff equivalents of the t_i and ϕ_i are not the same. To see this, consider imports of coal under NAFTA. Using the high elasticity assumption, Table 2 shows that entry into NAFTA results in a 6.5% reduction in the price of coal imports (i.e. $\phi = 0.937$). Since a cut in the uniform tariff from .11 to τ yields a value of $\phi = (1+\tau)/1.11$, a value of $\phi = .937$ translates to a new uniform tariff of 4 % (i.e. $\tau = (.937)(1.11) - 1 = .04$). Table 3 shows that this cut yields an average tariff of 2.7% per dollar of imports, which is equivalent to a uniform external tariff of $(2.7/(1 -.027)) = 2.77\%$. Similar calculations for the other import categories indicate that the uniform tariff equivalents of the t_i are consistently less than those of the ϕ_i.

A possible explanation for this example can be seen using a simple example in which there are only two source countries for an imported good, and there is no substitutability between source countries. Letting β_i be the share of imports from country i ($i = 1,2$), the value of the import price index for this case will be $\phi(\tau_1,\tau_2) = \beta_1\left(\frac{1+\tau_1}{1+\tau_1^0}\right) + \beta_2\left(\frac{1+\tau_2}{1+\tau_2^0}\right)$, where a 0 superscript denotes the initial tariff rate. Note in particular that for given initial tariff rates this index depends only on the import-weighted average value of the new tariffs (denoted $\bar{\tau}$), and not on the variance of the rates. The average tariff rate will be $t(\tau_1,\tau_2) = \beta_1\left(\frac{\tau_1}{1+\tau_1}\right) + \beta_2\left(\frac{\tau_2}{1+\tau_2}\right)$. Since $\tau/(1+\tau)$ is a concave function of τ, it follows from Jensen's inequality that $t(\tau_1, \tau_2) \leq t(\bar{\tau},\bar{\tau})$. This shows that the value calculated using the actual tariff data will be lower than that calculated using the trade-weighted average tariff when the tariff cut is not uniform, which means that the measure t depends on the variance of tariff rates even when the elasticity of substitution is 0. For cases in which $\sigma > 0$ this comparison becomes more complicated, because ϕ is no longer linear in τ. However, the calculations above suggests that the direction of the bias continues to hold for Chile in this case as well. This highlights the fact that calculation of the price index for imports is not sufficient for calculating the average tariff rate when tariffs are not uniform. It also suggests that the failure to use the tariff line data could result of overestimates of average tariff rates, if these average tariffs are estimated using the average price reduction on imported goods resulting from a tariff cut.

Two general conclusions emerge from the values of the ϕ_i and t_i calculated for Chile. First, the effect of eliminating tariffs on imports from NAFTA countries is more significant than the effect of eliminating tariffs on MERCOSUR countries. Second, the effect of these reductions was more significant under the high elasticity assumption than under the low elasticity assumption. This result held for both measures of tariff reductions.

II. The General Equilibrium Model of the Domestic Economy

In this section we present a simple general equilibrium model to use with the aggregated tariff indices calculated in the previous section, and use this model to calculate the impact of the tariff changes on factor prices, consumption levels, and welfare in Chile. The objective in formulating this general equilibrium model is to make the model sufficiently rich that it is capable of capturing the effects of tariff changes on consumption decisions and resource allocation between production sectors, while keeping the model simple enough that it can be calculated on an EXCEL spreadsheet. The specification of the model presented here is based on the data used for the case of Chile, but the formulation can easily be adjusted to allow greater or lesser detail as dictated by the availability of data. The data for domestic production was obtained from the input/output table for Chile for 1986, which contained data on the value of output, labor input, domestically produced intermediate inputs, and imported intermediate inputs for domestic production sectors. Data on domestic consumption by sector was also available, with consumption broken down between domestic and imported goods. This data was used to parameterize a specific factors general equilibrium model of the production structure.

A. The Model

In this section we present a general equilibrium production model for the domestic economy. We will divide the domestic production sector into two types of goods: traded and non-traded goods. Let I_T denote the total number of traded goods sectors, and I_N the number of non-traded goods sectors. For non-traded goods, all output is sold in the domestic market and the price of output will be endogenously determined by equating local production to domestic demand. For traded goods, output can be sold in the domestic market and the world market. We will assume that the price of traded goods sold in the world market is exogenously given, but that the price of traded goods sold in the domestic market is endogenously determined because exports and domestic sales are imperfect substitutes.

For each sector i, output (Y_i) is produced using labor (L_i), capital (K_i) and intermediate inputs from sectors j (X_{ij}, $j \in N,T$). Capital is assumed to be sector-specific, so that K_i is exogenously given in each sector, while labor is assumed to be mobile between sectors. The production function for each sector is assumed to take the CES form, and is given by

$$Y_i = \left[(b_{Ki}K_i)^{\frac{\sigma_i - 1}{\sigma_i}} + (b_{Li}L_i)^{\frac{\sigma_i - 1}{\sigma_i}} + \sum_{j=\in T,N} (b_{ji}X_{ji})^{\frac{\sigma_i - 1}{\sigma_i}} \right]^{\frac{\sigma_i}{\sigma_i - 1}} \tag{7a}$$

where the parameters b_{ji} are technological parameters reflecting the productivity of a unit of input j and σ_i is the elasticity of substitution between inputs. For inputs from non-traded goods sectors j, the input consists entirely of domestically produced goods. For inputs from traded goods sectors j, the intermediate input X_{ji} is a composite good made up of imported goods, X_{mji}, and domestically produced goods, X_{dji}, according to the relationship

$$X_{ji} = \left[(b_{dji}X_{dji})^{\frac{\sigma_{ji} - 1}{\sigma_{ji}}} + (b_{mji}X_{mji})^{\frac{\sigma_{ji} - 1}{\sigma_{ji}}} \right]^{\frac{\sigma_{ji}}{\sigma_{ji} - 1}} \tag{7b}$$

For sectors where traded goods are produced, the output may be sold either in the domestic market, Y_{di}, or exported to the world market, Y_{xi}. We assume that domestic and export sales are imperfect substitutes from the firm's point of view, so that for firms producing traded goods the output Y_i is a composite good representing the combination of domestic and export sales,

$$Y_i = \left[(m_{di} Y_{di})^{\frac{1+\sigma_{xi}}{\sigma_{xi}}} + (m_{xi} Y_{xi})^{\frac{1+\sigma_{xi}}{\sigma_{xi}}} \right]^{\frac{\sigma_{xi}}{\sigma_{xi}+1}} \tag{7c}$$

Imperfect substitutability between domestic sales and export sales can arise due to differences in quality or product characteristics between goods sold to domestic and foreign consumers, or because of transportation and packaging costs required for export sales.

Consumer's preferences are assumed to be represented by a CES utility function

$$U = \left[\sum_{i \in T,N} (a_i D_i)^{\frac{\sigma_C - 1}{\sigma_C}} \right]^{\frac{\sigma_C}{\sigma_C - 1}} \tag{8a}$$

where a_i are taste parameters and σ_C is the elasticity of substitution in consumption for final goods. For traded goods, it is assumed that imports are imperfect substitutes for domestically produced goods in the same sector. The consumption of a traded good, D_i for $i \in T$, is a composite good defined to be

$$D_i = \left[(a_{di} D_{di})^{\frac{\sigma_{Ci} - 1}{\sigma_{Ci}}} + (a_{mi} D_{mi})^{\frac{\sigma_{Ci} - 1}{\sigma_{Ci}}} \right]^{\frac{\sigma_{Ci}}{\sigma_{Ci} - 1}} \tag{8b}$$

where D_{mi} (D_{di}) is the consumption of imported (domestically produced consumption goods), a_{mi} (a_{di}) is the taste parameter for imported (domestic) consumption goods, and σ_{Ci} is the elasticity of substitution between imported and domestically produced consumption goods in sector i. By setting $\sigma_{Ci} > \sigma_C$ we obtain a greater degree of substitutability between domestically produced goods and imported goods in the same sector than between goods from different sectors. Consumption levels are chosen to maximize the utility function (8), subject to the constraint that the level of expenditure, E, not exceed the income of households. This yields the budget constraint

$$E \equiv \sum_{i \in N,T} D_i = \sum_{i \in N,T} r_i K_i + wL + B + \sum_{i \in T} t_i \phi_i \left(D_{mi} + \sum_{j \in N,T} X_{mij} \right) \tag{9}$$

where the aggregate household income is the sum of factor incomes (earnings of sector-specific capital and labor), borrowing, and tariff revenue. The tariff rates t_i in (9) are the tariff rates for the composite imports derived from the tariff line aggregation in Section I, while r_i is the rental on a unit of capital in sector i and w is the wage rate. The supplies of sector-specific capital and labor are taken as exogenously given, as is the level of borrowing.

The prices of exports from the home country traded goods producers, p_{xi} for $i \in T$, the price of imported inputs purchased by N firms and T firms, and the price of imported consumption goods are all taken as exogneously given by the small country assumption. The prices traded goods sold in the domestic market and the price of non-traded goods will be determined endogenously, as will the returns to the domestic factors of production. We will briefly describe the equilibrium conditions for the domestic factor markets and goods markets which are solved as part of the spreadsheet model. The complete derivation of the market-clearing conditions from the maximization problems of firms and households is presented in the Appendix.

The linkage between the goods markets and factor markets is shown in Figure 2, which illustrates a case in which there is only a single traded good sector, T, and a single non-traded sector, N. Consider first the factor markets. In the labor market, the fixed stock of labor must be allocated between employment in traded and non-traded goods sectors. Let $L_i(w,\mathbf{p},\phi, K_i)$ denote the demand for labor in sector i, which is derived from cost minimization problem of the firm given the wage rate, stock of sector-specific capital, the vector of prices of domestic goods ($\mathbf{p}$) and the vector of prices of imported goods (ϕ). The equilibrium condition requires that the sum of the sectoral demands equal the endowment of labor, L.

$$\sum_{i\in N,T} L_i(w,\mathbf{p},\boldsymbol{\phi},K_i) = L \tag{10}$$

Since capital is sector-specific and fixed in supply, its return can be determined from the zero profit conditions of the firm. Given output price and the prices of intermediate inputs and labor, the return to capital will be determined by the condition that price equal unit cost of production. These conditions can be expressed as

$$r_i = r_i(\mathbf{p},\boldsymbol{\phi},w) \tag{11}$$

Next consider the goods markets. The demand for non-traded good i comes from the household demand for i as consumption goods, D_i, and the sum over production sectors j of demand for i as an input $\sum_{j\in N,T} X_{dij}$. Sector j's demand function for intermediate inputs from sector i are derived from the cost-minimization problem of the firm, $X_{ij}(w,\mathbf{p},\phi, K_j)$. The supply of the non-traded good is similarly obtained from the optimization of firms in sector i, $Y_i(w,\mathbf{p},\phi, K_i)$. The (Hicksian) demand functions for the non-traded good for final consumption is derived from the consumer optimization problem, $D_i(\mathbf{p},\phi, U)$, where U is aggregate utility. Combining these behavioral relations, we obtain the market-clearing condition for non-traded goods sector i to be

$$D_i(\mathbf{p},\boldsymbol{\phi},U) + \sum_{j\in N,T} X_{ij}(\mathbf{p},\boldsymbol{\phi},w,K_j) = Y_i(\mathbf{p},\boldsymbol{\phi}w,K_i) \qquad \text{for } i \in N \tag{12a}$$

A similar market-clearing conditions exists for domestic sales of traded goods, except that we allow for substitutability between domestic goods and imports in consumption and intermediate demand, and for substitution between domestic sales and export sales in production. The market-clearing condition for this case will be

$$D_{di}(p,\Phi,U) + \sum_{j\epsilon N,T} X_{dij}(p,\Phi,w,K_j) = Y_{di}(p,\Phi w,K_i) \qquad \text{for } i \in T \qquad (12b)$$

In summary, equations (10)-(12) yield $2(I_N + I_T) + 1$ market-clearing conditions. These equations contain $2(I_N + I_T) + 2$ unknowns: the I_N prices of non-traded goods, I_T prices of domestic traded goods output, $I_T + I_N$ returns to sector-specific capital, the wage rate, and the level of aggregate utility. The remaining condition is obtained by noting that for the utility function (8), the level of aggregate utility is equal to expenditure deflated by a price index,

$$E = \phi_C U \tag{13}$$

where ϕ_C is the price index associated with the CES utility function. Substituting this condition in the budget constraint (9) yields the last equation.

Now suppose that there is trade liberalization, which lowers the prices of imported consumption and intermediate goods. At the initial equilibrium prices and utility level, consumers substitute away from domestically produced goods and toward imported goods, which would reduce final goods demand and tend to create excess supply of traded and non-traded goods in (12). Also, the reduction in the price of imported inputs will raise the supply of domestically produced goods at initial prices, which also tends to create excess supply in (12). However, the effect of the tariff reduction on the demand for domestic goods as intermediates is ambiguous: the increasing scale of domestic production will tend to raise intermediate demand, but the lower price of imports will result in substitution away from domestically produced inputs and toward imported inputs. In the labor market, the reduction in tariffs on imported goods will raise the profitability of production at fixed output prices, which raises the demand for labor. Prices of domestic factors and goods will adjust to eliminate the disequilibrium created by the trade liberalization.

It is clear that the direction of the change in prices of domestic goods and factors cannot be determined a priori. For example, the above discussion suggested that the excess demand for labor at initial prices would put upward pressure on the wage rate. However, if the price of domestic goods declines, as seems likely if the domestic goods are good substitutes for imports, the demand for labor will be reduced. Thus, wages and goods prices could either rise or fall in the final equilibrium. The discussion of the model does suggest several factors that are likely to affect the magnitude of the price changes. First, markets with greater levels of imports for final consumption and directly competing imported intermediates are likely to experience declines in prices, since there will be greater substitution away from domestic goods. This will also reduce the returns to owners of specific factors in these sectors, because of the decline in output price. Second, prices are also likely to fall in sectors where significant levels of imported inputs are used, because the reduction in production cost will increase supply. In these sectors specific factor owners will increase incomes, though, because the cost of inputs declines relative to the price of output. In this case imports will be a complement to domestic production rather than a substitute. Third, the impact on domestic prices is likely to be larger the greater is the elasticity of substitution between domestic goods and imported goods. Finally, the impact on prices is likely to be small when there is a significant level of exporting and a high elasticity of substitution between domestic sales and export sales.

We now turn to a parameterization of the model for the case of Chile, to illustrate how a preferential tariff reduction affects domestic prices once equilibrium has been restored in all markets.

B. Simulation Results for Chile

The domestic production data for Chile contained information on 69 domestic production sectors for Chile. Of these sectors, 41 produce traded goods and 28 sectors produce non-traded goods.[5] In order to economize on the number of endogenous variables and allow the equilibrium to be calculated on an EXCEL spreadsheet, the 69 production sectors were further aggregated into a total of 9 domestic production sectors. These 9 sectors are listed in Table 4, along with summary statistics indicating the relative size, labor intensity, and trade pattern for the respective industries. The first 6 sectors produce traded goods. Of these traded goods, the trade data suggests that Chile has comparative advantage in the first three sectors: mining, agriculture, and food products. Exports in each of these sectors represent at least 10% of output, and imports make up an insignificant share of local consumption. The mining sector alone accounts for more than half of all exports, primarily from copper. These exportable sectors represent slightly more than a quarter of value added.

The next three sectors traded goods sectors, textiles, machinery, and other manufacturing, are primarily import-competing sectors. Imports in the latter two groups account for more than three-quarters of total imports. These sectors differ quite substantially in their factor usage, so the impact of trade liberalization may well differ substantially across these sectors. Textiles are the most labor-intensive of these sectors, and use primarily unskilled labor. The machinery sector contains a number of high tech industries, while the other manufacturing sector is quite capital-intensive. The final three sectors represent non-traded goods: energy, services, and domestic transport. These sectors also differ substantially in factor usage, with energy being the most capital-intensive sector and services the most labor-intensive sector of all the 9 sectors.

The solutions for the wage rate and non-traded goods prices in the full simulation model are reported in Tables 5 and 6. Table 5 reports the solutions for the wage rate and non-traded goods prices for NAFTA and MERCOSUR tariff cuts under the assumption that the elasticity of substitution between domestically produced goods and imports is 2. The first column reports the effect of MERCOSUR tariff cuts using the high values for the elasticity of substitution between imports from different countries. Since all prices and the wage rate are unity in the initial situation, the solutions for this case reflect a decline in the wage rate of approximately .7%. Note that the numeraire in this exercise is the export price of traded goods, which is equal to unity throughout the simulation. Since consumer prices fall by approximately 1 percent, this results in a small increase in the real wage. The domestic prices of the import-competing goods showed the largest decline among the domestic sectors, with reductions of 1-1.6%. Non-traded goods fell by approximately 1%, while prices of exportables declined by about .5%. The smaller reduction in prices for exportables is probably due to the fact that as domestic demand declines, exportables can be sold more readily in the world market. The lower portion of column 1 shows the effect of MERCOSUR on sectoral employment and capital returns under the high between-country elasticity assumption. The primary loser from liberalization is the textile sector, where capital owners experience a loss in return of 1.6%. The mining sector is the primary gainer, with an increase in return of 1.27%. The major import-competing sectors and some of the non-traded goods sectors lose employment, and there seems to be a tendency for the more labor intensive sectors (as identified in Table 4) to experience larger losses. Overall, tariff preferences for MERCOSUR countries results in a small loss in aggregate welfare (-.168 %).

The second column reports simulation results for the case in which the elasticity of substitution between source countries takes the low value. In this case the loss in tariff revenue and aggregate welfare is smaller than in the high elasticity case, which could be interpreted as resulting from less trade diversion when the elasticity of substitution is lower. The price effects of liberalization are also lower in this case, although the pattern of sectoral impacts is the same.

The third and fourth columns report results for Chile's entry into NAFTA. The declines in consumer prices and tariff revenue are slightly larger than for the case of MERCOSUR, which is consistent with the conclusion of Section I that NAFTA would result in greater reductions in prices of importable and greater declines in average tariff rates. The major difference in sectoral impacts seems to be that agricultural and food products sectors do better under NAFTA than under MERCOSUR. As in the case of MERCOSUR, the welfare losses are smaller when the elasticity of substitution between source countries is low.

The final column of Table 5 reports the effect of a complete elimination of trade barriers. Since there is a uniform tariff in Chile in the initial situation, the relative prices of imports from different countries are not affected by a movement to free trade and the result is independent of the assumption made regarding the elasticity of substitution between source countries. Complete elimination of trade barriers raises the return to capital in mining by more than 5%, and causes the return to capital in textiles to fall by 4.5%. The directions of changes in sectoral factor returns for a movement to free trade are generally similar to those for NAFTA, but the magnitudes are 2-3 times larger for the free trade case.

Table 6 reports results under the assumption that the elasticity of substitution between domestic and imported goods is 4. This higher elasticity assumption results in greater substitution toward imported goods as a whole as a result of tariff reductions, which can be thought of as additional trade creation. This results in a greater benefit from preferential liberalization, so that NAFTA results in a very small welfare gain under the low between-source country elasticity assumption. The sectoral impacts of trade liberalization are generally larger for this case, particularly for the machinery sector where losses are nearly as large as those in the textile sector.

Overall, the following conclusions emerge from this simulation concerning the effects of NAFTA and MERCOSUR on Chile. First, the effects of eliminating tariffs on either NAFTA or MERCOSUR members has a very small impact on aggregate welfare, and the effect could be either positive or negative. The ambiguity centers around the assumptions made regarding the elasticity of substitution between source country imports and the elasticity of substitution between domestic goods and imports. Increases in the former elasticity reduce the benefits obtained from preferential relationship because they increase trade diversion, while increases in the latter elasticity raise the benefits of a preferential relation because they increase trade creation.

Second, the impact of these trade agreements on production sectors are somewhat more significant, and generally similar across agreements. Under either agreement, there is some flow of labor out of import-competing (primarily textile and machinery) and non-traded goods (services and transportation) and into exportable (mining and food products) sectors. The major difference between the two agreements seems to be that NAFTA has a more favorable impact on the agricultural sector, but a more unfavorable effect on the other manufacturing sector (primarily chemicals). This reflects the differences in comparative advantage of the NAFTA and MERCOSUR countries.

Third, the sectoral effects of either of these agreements is significantly smaller than the one that would result form a complete elimination of trade barriers. The negative impact on the textile and machinery sectors of free trade would be several times larger than that of either preferential agreement (even under high assumptions regarding the degree of trade diversion), probably because of the presence of important suppliers in Europe and Asia that would not be part of either preferential arrangement.

It should be emphasized that the results reported above do not include the gains to Chile generated by improvements in the terms of trade resulting from tariff cuts in partner countries. For the case of NAFTA, suppose we view the US domestic price as being the world price of exports. A reduction in the US tariff will allow Chile to sell its exports at the US domestic price, which result in a terms of trade improvement for Chile. Incorporation of this effect is likely to increase the attractiveness of NAFTA relative to MERCOSUR, given the greater size of the US market. Effects of this type could be incorporated by utilizing data on the tariffs faced by Chile in the partner market. In the NAFTA case, it would seem reasonable to model the terms of trade improvement for Chile as the amount of the reduction in the US tariff. For Mercosur, where Chile is likely to have a significant impact on prices in partner countries, it would be preferable to endogenize the prices in the partner countries. For example, Harrison, Rutherford, and Tarr (1996) find that the effects of access for Chile is sufficient to make entry into NAFTA desirable. Their conclusions regarding the effects of entry in to MERCOSUR (with improved market access to partner countries) were mixed, with gains arising under some elasticity assumptions but not under others.[6]

III. Conclusions

This paper has presented an index for aggregating tariff data to use in the analysis of preferential trading arrangements, and illustrated how the index can be combined with a general equilibrium model of the domestic economy that can be run on an EXCEL spreadsheet. The calculations for the case of Chile suggest that the index is simple to calculate due to its recursive structure, which allows large amounts of detailed tariff line data to be aggregated to be used with domestic production data which is only available at a much more aggregated level. It was also found that results using the tariff aggregators may differ substantially from those obtained using simple averages of tariff reductions. For example, the reductions in import prices using the index were ranged from 10-30% larger than those calculated using a simple average of tariffs, depending on the assumptions made regarding elasticity of substitution between source countries. Furthermore, there were substantial differences between the uniform tariff rate equivalent of the import price reduction and the uniform tariff rate equivalent of the average tariff rate for industries. This means that ignoring the information available in tariff line data could result in a substantial overestimate of the average tariff rate on imports when a preferential reduction is made.

The use of this tariff index data in the spreadsheet model for Chile indicated that it is possible to set up a general equilibrium model using 9 domestic sectors with a CES specification of technology and preferences that can be solved easily on an EXCEL spreadsheet. The spreadsheet model produced plausible results concerning the effects of trade liberalization on domestic goods prices and factor returns, and indicated that the welfare effects of the proposed trade agreements would have aggregate welfare consequences. In particular, the direction of welfare change depends on elasticities of substitution that correspond approximately to notions of trade creation and trade diversion.

The results of this work suggest several directions in which the work might be extended. First, the tariff index could be extended to incorporate the role of quantitative restrictions. If data on the initial tariff-equivalents of quantitative restrictions are available, then the initial levels of restrictions can be calculated using the index. However, these levels of protection will change in response to changes in the level of protection of other goods, because the domestic price of imported goods is endogenous for a small country in the presence of quantitative restrictions. Further work exploring ways in which this endogeneity could be incorporated into the index would be useful.

Second, it would be useful to be able to link spreadsheet calculations for different countries in order to be able to endogenize some of the prices. For example, in the MERCOSUR case it would be useful to be able to solve for some prices within MERCOSUR countries as part of the calculations, since Chile's size relative to these countries may be sufficient to have an impact on prices in these markets. Finally, the general equilibrium model makes a specific factors assumption regarding domestic capital. It would be useful to consider the effects on domestic production of allowing reallocation of capital between industries over time. Presumably, this would lead to larger effects of trade liberalization on the composition of domestic production, and possibly also to larger welfare effects of liberalization.

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Endnotes

1.Corden (1984) provides a survey of the customs union literature, and documents a number of attempts to identify concepts of "trade creation" and "trade diversion" in specific trade models.

2.The year 1986 was chosen because it is the most recent year for which a comprehensive input/output table for the Chilean economy was available. The trade data for 1986 was used because it was compatible with the input/output data.

3. At the tariff line level, there are likely to be zero imports from many countries. This is handled by setting $b_{ij} = 0$ or $q_{ij} = \infty$ for countries that are not sources of supply. In this case, we must have the elasticity of substitution greater than 1 to yield a positive value of Z_i.

4.The assumptions regarding σ_i and σ_{ij} were held constant for the low elasticity and high elasticity assumptions. These elasticities refer to substitution between products from different sub-industries categories, and these values were chosen to be consistent with the assumptions made regarding substitution between products in the domestic production model.

5. The industry classification used in the Chilean input/output system did not correspond exactly to those used in SITC classifications, so it was not possible to match exactly some of the sectors in the input/output table with those in the trade data. To deal with this problem, several sectors in the Chilean data were aggregated to make them compatible with SITC classifications. For example, it could not determined how the SITC classifications of chemical products should be divided between the "chemical products" and "other chemical products" industries in Chilean data. Therefore, the industries were combined into a single chemical products industry. This process reduced the total number of traded goods sectors from 47 to 41. A check on the quality of the match between trade data and the production data was available by comparing the allocation of imports across sectors in the trade data with that reported in the input/output tables. The results indicated a very close association between trade shares using the trade data and that using the input/output tables.

6. Harrison, Rutherford, and Tarr (1996) utilize a global general equilibrium model to calculate the effect of Chile's entry into various forms of preferential trading arrangements. In the case where Chile does not obtain preferred access to partner markets, they reach a similar conclusion to the results of this paper regarding Chile's entry into Mercosur or Nafta. They find losses for entry into either arrangement, with the magnitudes being somewhat larger than those found in this paper. The larger magnitude of losses appears to be related to their assumption of higher elasticities of substitution between products from different countries. Their high elasticity assumption uses a value of 30, which is substantially higher than existing econometric estimates, and might be interpreted as a long run elasticity of substitution.

Appendix

In this section we present the market-clearing conditions which are required to solve for the endogenous variables in the spreadsheet CGE model.

A. Production Structure

A firm in a non-traded goods sector faces a given output price p_i and given prices of inputs of labor, w, capital, r_i, and composite intermediate inputs, q_{ji}. Under the assumption of constant returns to scale, the firm will choose its input usage to minimize unit cost. The CES production function (7a) has the associated unit cost function

$$\Gamma_i \equiv \left[\left(\frac{r_i}{b_{Ki}}\right)^{1-\sigma_i} + \left(\frac{w}{b_{Li}}\right)^{1-\sigma_i} + \sum_{i\in T,N}\left(\frac{q_{ji}}{b_{ji}}\right)^{1-\sigma_i}\right]^{\frac{1}{1-\sigma_i}} \tag{A.1}$$

where Γ_i is the cost of a unit of output in sector i. Since the industries are assumed to be perfectly competitive, $p_i = \Gamma_i$ in equilibrium.

A firm in a traded goods sector faces given prices for domestic sales, p_{di}, and export sales, p_{xi}, and given input prices w, r_i, and q_{ji}. The firm's profits will be

$$p_{di}Y_{di} + p_{xi}Y_{xi} - wL_i - r_iK_i - \sum_{j\in T,N} q_{ji}X_{ji} \ .$$

From the separability of the production function, this optimization problem can be decomposed into the two part optimization problem:

(I) $$\min_{K_i,L_i,X_{ji}} \quad wL_i + r_iK_i + \sum_{j\in N,T} q_{ji}X_{ji}$$

$$\text{subject to} \left[\left(b_{Ki}K_i\right)^{\frac{\sigma_i-1}{\sigma_i}} + \left(b_{Li}L_i\right)^{\frac{\sigma_i-1}{\sigma_i}} + \sum_{j=\in T,N} \left(b_{ji}X_{ji}\right)^{\frac{\sigma_i-1}{\sigma_i}} \right]^{\frac{\sigma_i}{\sigma_i-1}} \geq Y_i$$

(II)

$$\max_{Y_{xi}, Y_{di}} \quad p_{xi}Y_{xi} + p_{di}Y_{di}$$

$$\text{subject to} \left[\left(m_{di}Y_{di}\right)^{\frac{1+\sigma_{xi}}{\sigma_{xi}}} + \left(m_{xi}Y_{xi}\right)^{\frac{1+\sigma_{xi}}{\sigma_{xi}}} \right]^{\frac{\sigma_{xi}}{\sigma_{xi}+1}} \leq Y_i$$

The firm's cost-minimization problem (I) yields the unit cost function Γ_i as in (A.1) for the non-traded sector. The optimal solution to the output allocation problem (II) yields a revenue level p_iY_i, where

$$p_i = \left[\left(\frac{p_{di}}{m_{di}}\right)^{1+\sigma_{xi}} + \left(\frac{p_{xi}}{m_{xi}}\right)^{1+\sigma_{xi}} \right]^{\frac{1}{1+\sigma_{xi}}} \qquad \text{for } i \in T \qquad \text{(A.2)}$$

is the unit value of the composite output good. In a competitive traded goods industry, Γ_i will equal p_i in equilibrium.

The unit cost functions and unit revenue functions can now be used to derive the cost shares of the respective inputs and the revenue shares of outputs in the traded goods industries. Defining $\theta_{ji} = q_{ji}X_{ji}/p_iY_i$ to be the shares of costs of the intermediate goods in total costs, we differentiate can apply Shephard's lemma to the unit cost function Γ_i to obtain $\theta_{ji} = \left(\frac{q_{ji}}{b_{ji}\Gamma_i}\right)^{1-\sigma_i}$. Similar expressions can be derived for labor's share of total costs, θ_{Li}, and capital's share of total costs, θ_{Ki}. Following the procedure used in the aggregation of imports, we normalize all prices to unity in the initial situation, yielding $(b_{ji})^{\sigma_i-1} = \theta^0_{ji}$ for $j \in$ T,N and j = K,L. The demands for the inputs can thus be expressed in terms of the cost shares as

$$\theta_{Ki} = \theta^0_{Ki}\left(\frac{r_i}{\Gamma_i}\right)^{1-\sigma_i}, \quad \theta_{Li} = \theta^0_{Li}\left(\frac{w}{\Gamma_i}\right)^{1-\sigma_i}, \quad \theta_{ji} = \theta^0_{ji}\left(\frac{q_{ji}}{\Gamma_i}\right)^{1-\sigma_i} \quad \text{for } i,j \in T, N \qquad (A.3)$$

Similarly, define $\mu_{ki} = p_{ki}Y_{ki}/p_iY_i$ to be the share of revenues from sales in the k market (k = d,x) in total revenue. Differentiating (A.2) with respect to the output prices yields

$$\mu_{xi} \equiv \frac{p_{xi}Y_{xi}}{p_iY_i} = \mu^0_{xi}\left(\frac{p_{xi}}{p_i}\right)^{1+\sigma_{xi}} \qquad \mu_{di} \equiv \frac{p_{di}Y_{di}}{p_iY_i} = \mu^0_{di}\left(\frac{p_{di}}{p_i}\right)^{1+\sigma_{xi}} \qquad \text{for } i \in T \qquad (A.4)$$

where $\mu^0_{ki} = m_{ki}^{-(\sigma_x+1)}$ is the share of sales in the k market in the initial situation.

We now turn to the definition of the intermediate inputs. Intermediate inputs of traded goods may either be domestically produced or imported. In order to allow for imperfect substitutability between imported and domestic intermediates, we use the composite intermediate function given by (7b) in the text. The unit price of a unit of the composite input good will equal its unit cost, which is the unit cost function for the function (7b),

$$q_{ji} = \left[\beta^0_{dji}(p_{dj})^{1-\sigma_{ji}} + \beta^0_{mji}(\phi_{ji})^{1-\sigma_{ji}}\right]^{\frac{1}{1-\sigma_{ji}}} \qquad \text{for } i \in T,N;\ j \in T \qquad (A.5)$$

where $\beta^0_{kji} = b_{kji}^{\sigma_{ji}-1}$ is the share of costs of inputs from source k (k = d,m) in total cost of inputs

from sector j used in sector i and σ_{ji} is the elasticity of substitution between domestically produced and imported inputs. The price of imported goods, ϕ_{ji}, is the price index obtained from the aggregation of tariff line data in Section I. Note that the input prices q_{ji} will be sector-specific, in that the shares of imported goods in the input bundle and the composition of the import bundle may differ across production sectors. Differentiating (A.5), we obtain the shares of the respective sources in total purchases from sector j to be

$$\beta_{dji} = \beta_{dji}^{0}\left(\frac{p_{dj}}{q_{ji}}\right)^{1-\sigma_{ji}}, \quad \beta_{mji} = \beta_{mji}^{0}\left(\frac{\phi_{j}}{q_{ji}}\right)^{1-\sigma_{ji}} \quad \text{for } i \in T,N;\ j \in T \qquad (A.6)$$

The cost share of domestic (imported) intermediates in total costs will thus be $\beta_{dji}\theta_{ji}$ $(\beta_{mji}\theta_{ji})$. For inputs purchased from non-traded goods industries, the only source is domestic firms so $q_{ji} = p_j$ for $j \in N$ and $i \in T, N$.

Equations (A.1) - (A.6) characterize the profit-maximizing choices of input usage and output composition for firms in the traded and non-traded goods sectors. These condition can also be used to solve for the equilibrium returns to sector-specific capital. Under the assumption that firms in sector i are perfectly competitive, $p_i = \Gamma_i$ and we can express the total return to a unit of capital as

$$r_i = \left[\left(\frac{p_i^{1-\sigma_i}}{\theta_{Ki}^{0}}\right) - \left(\frac{\theta_{Li}^{0} w^{1-\sigma_i}}{\theta_{Ki}^{0}}\right) - \sum_{j \in T,N}\left(\frac{\theta_{ji}^{0} q_{ji}^{1-\sigma_i}}{\theta_{Ki}^{0}}\right)\right]^{\frac{1}{1-\sigma_i}} \qquad \text{for } i \in T, N \qquad (A.7)$$

Note that (A.6) captures the effect of changes in the tariff structure on the return to sector-specific capital. The greater is the reduction in the price of imported inputs resulting from trade liberalization, as reflected by changes in , p_{ji}, the greater will be the increase in return to capital. Since $r_i^0 = 1$, K_i equals the return to capital in the initial situation under this choice of units.

B. Consumer Preferences and the Domestic Welfare Index

The CES utility function (8) has the associated price index

$$\phi_C = \left[\sum_{i \in T,N} \left(\frac{p_i}{a_i}\right)^{1-\sigma_C}\right]^{\frac{1}{1-\sigma_C}} \tag{A.8a}$$

and

$$p_i \equiv \left[\left(\frac{q_i}{a_{di}}\right)^{1-\sigma_{Ci}} + \left(\frac{\phi_i}{a_{mi}}\right)^{1-\sigma_{Ci}}\right]^{\frac{1}{1-\sigma_{Ci}}} \quad \text{for } i \in T \tag{A.8b}$$

Using Shepard's Lemma, we can express the budget shares in consumption for non-traded goods from (A.8) to be

$$\alpha_i \equiv \frac{p_i D_i}{E} = \alpha_i^0 \left(\frac{p_i}{\phi_C}\right)^{1-\sigma_C} \qquad i \in N \tag{A.9a}$$

For traded goods, we have the share of domestic and imported goods in consumption to be

$$\alpha_{di} \equiv \frac{q_i D_{di}}{E} = \alpha_{di}^0 \left(\frac{q_i}{p_i}\right)^{1-\sigma_{Ci}} \left(\frac{p_i}{\phi_C}\right)^{1-\sigma_C} \quad \alpha_{mi} \equiv \frac{\phi_i D_{mi}}{E} = \alpha_{mi}^0 \left(\frac{\phi_i}{p_i}\right)^{1-\sigma_{Ci}} \left(\frac{p_i}{\phi_C}\right)^{1-\sigma_C} \qquad i \in T \tag{A.9b}$$

The budget constraint requires that expenditure equal the sum of factor incomes, borrowing (B), and tariff revenue,

$$E = \sum_{i \in T,N} r_i K_i + wL + B + \sum_{i \in T} t_i \left(D_{mi} + \sum_{j \in N,T} X_{mij}\right) \tag{A.10}$$

Since the imported goods are composite goods obtained from aggregation of the tariff data, the tariff rates, ti are the tariff indices derived in Section I. From the definition of the expenditure function, we have $E = \phi_C U$ where ϕ_C is the price index in (A.8a). Using the demand function for imported consumption goods (A.10) and inputs ((A.2) and (A.4)), (A.10) can be rewritten as

$$U = \frac{wL + B + \sum_{i\in N,T} r_i K_i \left[1 + \sum_{j\in M} t_i\, \beta_{mji}\left(\frac{\theta_{ji}}{\theta_{Ki}}\right)\right]}{\phi\left[1 - \sum_{i\in M} t_i \alpha_{mi}\right]} \tag{A.11}$$

C. Market-Clearing Conditions

The behavioral relations derived from the CES preferences and technology above can be substituted into the market-clearing conditions to yield solutions for the impact of changes in policy on domestic prices and welfare. There are $2(I_N + I_T) + 1$ endogenous prices: I_N prices of non-traded goods, $I_N + I_T$ rental values on sector -specific capital, I_T prices of traded goods sold in the domestic market, and the wage rate. In addition, the level of domestic utility must be derived. The solutions for the rental values r_i are given by (A.7). In this section we derive the remaining market-clearing conditions for the labor market and markets for non-traded goods that are required to solve the general equilibrium model.

The labor market equilibrium requires that the sum of the labor demands across the $I_N + I_T$ domestic production sectors equal the exogenously given labor supply, L. The expenditure on labor in sector i can be expressed as $K_i r_i\ (\theta_{Li}/\ \theta_{Ki})$. Using this expression, we can write the labor market equilibrium as

$$\sum_{i\in T,N} K_i r_i \left(\frac{\theta_{Li}}{\theta_{Ki}}\right) = wL \tag{A.12}$$

where factor returns (A.7) and factor demands (A.2) can be substituted into (A.12).

The demand for non-traded goods in sector i $\in$ N is the sum of consumption demand and intermediate demand from the domestic production sectors, which yields the market equilibrium condition $D_i + \sum_{j \in T,N} X_{ij} = Y_i$. Multiplying both sides by p_i, this condition can be expressed as

$$\alpha_i E + \sum_{j \in T,N} r_j K_j \left(\frac{\theta_{ij}}{\theta_{Kj}} \right) = \frac{r_i K_i}{\theta_{Ki}} \qquad \text{for } i \in N \qquad (A.13)$$

The demand for non-traded consumption goods is given by (A.9), and the demand for intermediate inputs and the supply of non-traded goods are obtained from the factor demands (A.2). For traded goods, the market-clearing condition requires that demand for domestically produced traded goods by households and firms equal the supply of output to the domestic market, $D_{di} + \sum_{j \in T,N} X_{dij} = Y_{di}$.

Substituting from (A.9), (A.2), (A.4) and (A.6) yields

$$\alpha_{di} E + \sum_{j \in T,N} r_j K_j \left(\frac{\beta_{dij} \theta_{ij}}{\theta_{Kj}} \right) = r_i K_i \left(\frac{\beta_{di}}{\theta_{Ki}} \right) \qquad \text{for } i \in T \qquad (A.14)$$

Equations (A.7) and (A.11)-(A.14) are $2(I_T + I_N) + 2$ equations that can be solved on an EXCEL spreadsheet for the endogenous variables r_i (i $\in$ N, T) , p_i (i $\in$ N), p_{di} (i $\in$ T) , w, and U.

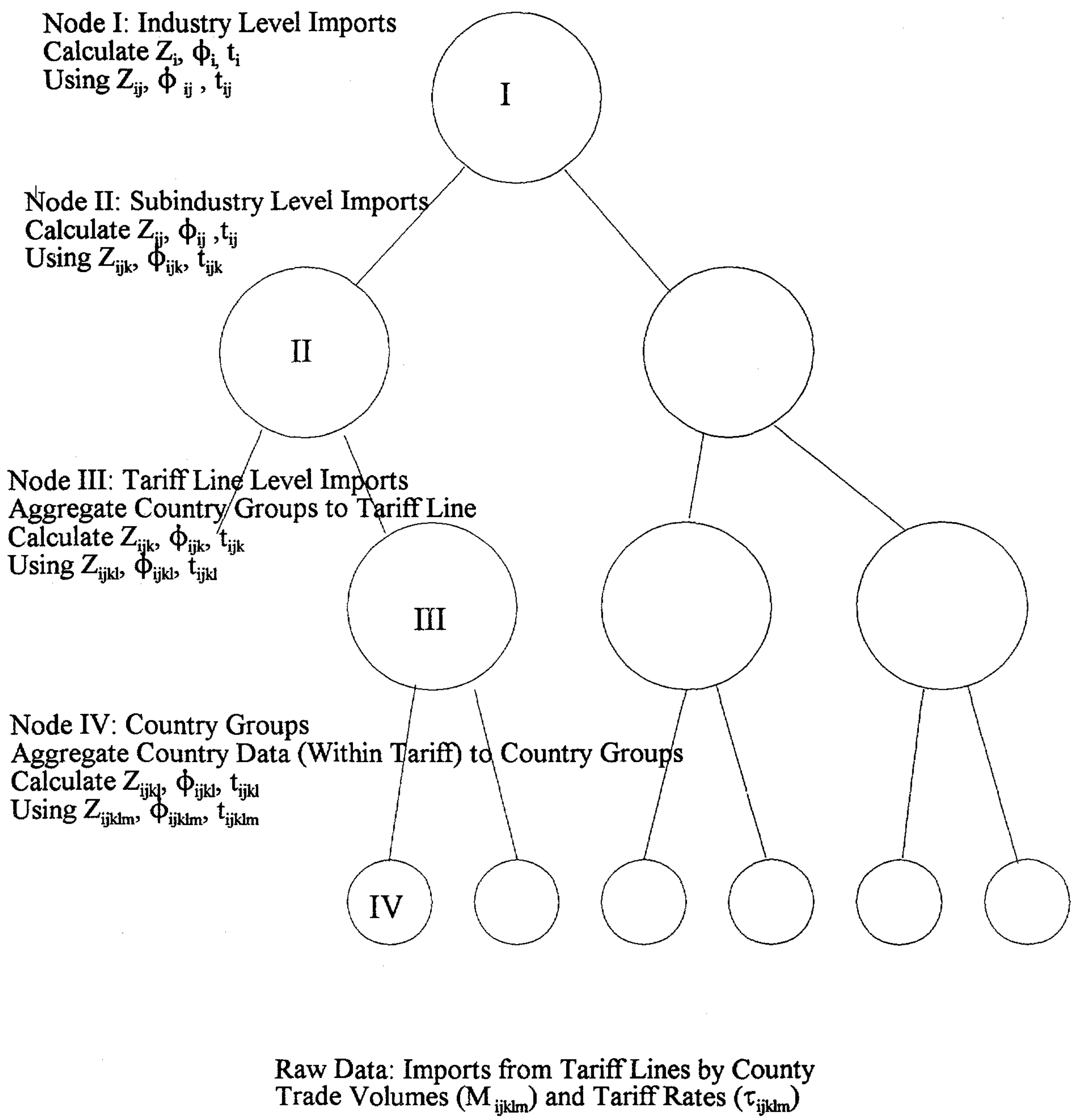

Figure 1 Aggregation Tree Structure

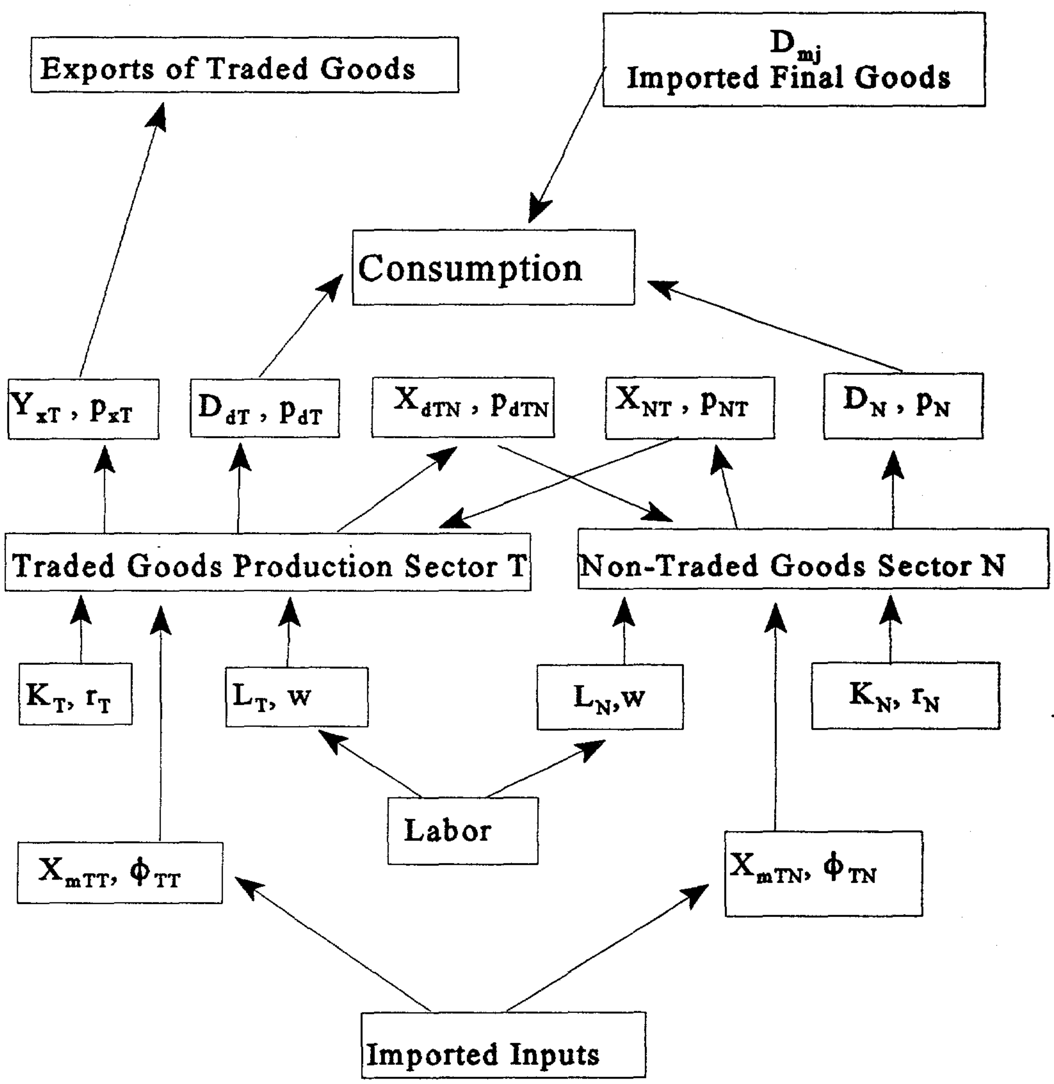

Figure 2 Factor and Goods Flows with 2 Production Sectors

Effects of Tariff Cuts to MERCOSUR Countries on Import Prices

Commodity	Share of Import	Base Rate	New Average Rate	ln(1+New) -ln (1+Base)	lnRelPri Low Elas	lnRelPri High Elas
non-elec mach	0.165	0.11	0.102	-0.008	-0.009	-0.014
chemicals	0.132	0.11	0.098	-0.011	-0.012	-0.017
elec mach	0.109	0.11	0.100	-0.009	-0.011	-0.017
oil and gas	0.094	0.11	0.110	-0.000	-0.000	-0.000
basic metals	0.085	0.11	0.089	-0.019	-0.022	-0.030
transp equip	0.077	0.11	0.082	-0.025	-0.028	-0.036
textile mfg	0.064	0.11	0.081	-0.026	-0.029	-0.039
plastic prod	0.044	0.11	0.087	-0.020	-0.024	-0.032
scientific equip	0.039	0.11	0.099	-0.010	-0.012	-0.017
petro prod	0.032	0.11	0.104	-0.005	-0.006	-0.007
ag	0.028	0.11	0.081	-0.027	-0.029	-0.033
paper prod	0.022	0.11	0.081	-0.026	-0.030	-0.039
rubber	0.021	0.11	0.090	-0.018	-0.021	-0.030
other mfg	0.014	0.11	0.102	-0.008	-0.009	-0.014
coal	0.011	0.11	0.110	-0.000	0.000	0.000
Average		0.11	0.094	-0.014	-0.016	-0.022
Uniform Tariff Equivalent		0.11	0.094		0.092	0.086

Table 1

Effects of entry into NAFTA on Import Prices

Commodity	Share of Imports	Base Rate	New Average Rate	ln (BASE) -ln(NEW)	ln Rel Pri Low Elas	ln Rel Price High Elas
non-elec mach	0.165	0.11	0.079	-0.028	-0.032	-0.044
chemicals	0.132	0.11	0.066	-0.041	-0.044	-0.053
elec mach	0.109	0.11	0.074	-0.033	-0.037	-0.047
oil and gas	0.094	0.11	0.110	-0.000	-0.000	-0.000
basic metals	0.085	0.11	0.091	-0.018	-0.021	-0.029
transp equip	0.077	0.11	0.096	-0.013	-0.015	-0.023
textile mfg	0.064	0.11	0.089	-0.019	-0.022	-0.030
plastic prod	0.044	0.11	0.079	-0.028	-0.033	-0.045
scientific equip	0.039	0.11	0.075	-0.032	-0.036	-0.047
petro prod	0.032	0.11	0.084	-0.024	-0.028	-0.040
ag	0.028	0.11	0.070	-0.036	-0.038	-0.041
paper prod	0.022	0.11	0.089	-0.019	-0.022	-0.031
rubber	0.021	0.11	0.089	-0.019	-0.022	-0.030
other mfg	0.014	0.11	0.067	-0.040	-0.044	-0.053
coal	0.011	0.11	0.056	-0.050	-0.055	-0.065
Average		0.110	0.083	-0.025	-0.028	-0.036
Uniform Tariff Equivalent		0.110	0.083		0.080	0.070

Table 2

Average Tariff Rates

Commodity	Share of Imports	Old Tariff	MERCOSUR Low Elas	MERCOSUR High Elas	NAFTA Low Elas	NAFTA High Elas
non-elec mach	0.165	0.099	0.089	0.077	0.066	0.044
chemicals	0.132	0.099	0.086	0.076	0.055	0.038
elec mach	0.109	0.099	0.088	0.074	0.062	0.042
oil and gas	0.094	0.099	0.099	0.099	0.099	0.099
basic metals	0.085	0.099	0.077	0.059	0.078	0.060
transp equip	0.077	0.099	0.070	0.055	0.083	0.067
textile mfg	0.064	0.099	0.069	0.051	0.076	0.060
plastic prod	0.044	0.099	0.075	0.057	0.065	0.040
scientific equip	0.039	0.099	0.087	0.076	0.062	0.041
petro prod	0.032	0.099	0.093	0.091	0.070	0.046
ag	0.028	0.099	0.070	0.063	0.062	0.057
paper prod	0.022	0.099	0.069	0.051	0.076	0.058
rubber	0.021	0.099	0.077	0.058	0.076	0.059
other mfg	0.014	0.099	0.089	0.077	0.055	0.037
coal	0.011	0.099	0.099	0.099	0.044	0.027
Average		0.099	0.082	0.071	0.071	0.054
Uniform Tariff Equivalent		0.11	0.090	0.076	0.076	0.057

Table 3

Characteristics of Domestic Production Sectors for Chile

	Share of Value Added	Exports / Gross Outpu	Imports/ Gross Outpu	Imported I Gross Out	Final Import Consumptio	Wages/ Value Ad
Agriculture	0.096	0.169	0.032	0.065	0.032	0.273
Mining	0.111	0.709	0.131	0.096	0.041	0.294
Food Products	0.055	0.181	0.041	0.071	0.022	0.363
Textiles/Footwear	0.023	0.009	0.242	0.194	0.133	0.433
Metals & Machinery	0.032	0.086	1.342	0.198	0.747	0.381
Other Manufacturing	0.082	0.122	0.375	0.241	0.073	0.308
International Transp	0.015	0.611		0.106		0.395
Energy	0.041			0.016		0.182
Services	0.438			0.031		0.480
Domestic Transport	0.110			0.065		0.363
				0.084		

Table 4

Simulation Results: Elasticty of Substitution Between Domestic and Imports = 2

	MERCOSUR High Elas	MERCOSUR Low Elas	NAFTA High Ela	NAFTA Low Elas	Free Trade
Wage	0.993	0.996	0.995	0.998	0.985
Price of Ag	0.994	0.996	0.996	0.997	0.980
Price of Minerals	0.997	0.998	0.998	0.999	0.984
Price of Food Products	0.989	0.993	0.992	0.995	0.968
Price of Textiles	0.984	0.989	0.983	0.988	0.950
Price of Machinery	0.987	0.992	0.985	0.989	0.951
Price of Other Mfg.	0.991	0.994	0.988	0.991	0.954
Price of Energy	0.991	0.995	0.990	0.995	0.973
Price of Services	0.990	0.994	0.989	0.993	0.966
Price of Transport	0.989	0.993	0.988	0.992	0.963
Old Tariff Revenue	78272	78272	78272	78272	78272
New Tariff Revenue	56705	65703	43209	56297	0
% Change in Welfare	-0.168	-0.010	-0.214	-0.002	0.155
%Employment Change in :					
Agriculture	0.642	0.368	1.166	0.722	2.086
Mining	1.743	1.033	2.116	1.323	5.829
Food Products	0.411	0.251	1.042	0.694	1.505
Textiles/Footwear	-0.873	-0.617	-0.694	-0.454	-2.700
Metals & Machinery	-0.139	-0.156	0.195	0.047	-1.238
Other Manufacturing	0.218	0.100	0.565	0.317	1.129
Energy	0.039	0.025	-0.020	-0.011	0.098
Services	-0.381	-0.217	-0.616	-0.378	-1.365
Domestic Transport	-0.305	-0.172	-0.512	-0.313	-1.095
% Change in Capital Return:					
Agriculture	0.043	0.055	0.821	0.610	0.851
Mining	1.266	0.795	1.876	1.278	5.010
Food Products	-0.214	-0.075	0.683	0.580	0.206
Textiles/Footwear	-1.640	-1.038	-1.246	-0.696	-4.466
Metals & Machinery	-0.825	-0.527	-0.258	-0.139	-2.842
Other Manufacturing	-0.428	-0.243	0.152	0.161	-0.212
Energy	-0.627	-0.325	-0.498	-0.203	-1.358
Services	-1.094	-0.594	-1.160	-0.612	-2.982
Domestic Transport	-1.010	-0.544	-1.044	-0.540	-2.682
% Change in Consumer Pri	-1.089	-0.684	-1.239	-0.803	-3.817

Table 5

Simulation Results: Elasticity of Substitution Between Domestic and Imports = 4

	MERCOSUR High Elas	MERCOSUR Low Elas	NAFTA High Elas	NAFTA Low Elas	Free Trade
Wage	0.991	0.995	0.993	0.996	0.977
Price of Ag	0.991	0.994	0.995	0.996	0.972
Price of Minerals	0.997	0.998	0.997	0.997	0.972
Price of Food Products	0.986	0.990	0.990	0.993	0.959
Price of Textiles	0.980	0.986	0.981	0.987	0.939
Price of Machinery	0.984	0.989	0.980	0.985	0.935
Price of Other Mfg.	0.989	0.992	0.983	0.988	0.942
Price of Energy	0.989	0.993	0.988	0.993	0.964
Price of Services	0.988	0.992	0.986	0.991	0.957
Price of Transport	0.987	0.991	0.985	0.990	0.954
Old Tariff Revenue	78272	78272	78272	78272	78272
New Tariff Revenue	56928	65943	43734	56902	0
%Change in Welfare	-0.158	0.000	-0.188	0.024	0.199
%Employment Change in :					
Agriculture	0.663	0.360	1.407	0.892	2.499
Mining	2.142	1.368	2.559	1.669	7.101
Food Products	0.309	0.134	1.352	0.946	1.973
Textiles/Footwear	-1.532	-1.153	-0.838	-0.578	-4.400
Metals & Machinery	-0.620	-0.499	-0.749	-0.662	-3.729
Other Manufacturing	0.053	-0.031	-0.227	-0.331	-0.116
Energy	0.085	0.065	0.015	0.018	0.214
Services	-0.377	-0.213	-0.611	-0.370	-1.376
Domestic Transport	-0.287	-0.156	-0.499	-0.300	-1.064
% Change in Capital Return:					
Agriculture	-0.159	-0.144	0.860	0.618	0.459
Mining	1.485	0.976	2.140	1.482	5.573
Food Products	-0.551	-0.395	0.799	0.678	-0.125
Textiles/Footwear	-2.597	-1.825	-1.635	-1.015	-7.206
Metals & Machinery	-1.584	-1.099	-1.536	-1.109	-6.460
Other Manufacturing	-0.836	-0.579	-0.955	-0.741	-2.446
Energy	-0.801	-0.472	-0.687	-0.353	-2.079
Services	-1.314	-0.780	-1.382	-0.784	-3.845
Domestic Transport	-1.214	-0.718	-1.259	-0.707	-3.499
% Change in Consumer Pri	-1.302	-0.866	-1.468	-0.985	-4.680

Table 6

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